Space Weather Technical Forecast

Issued on Monday 6 January 2025 at 13:13 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: M-class flares expected, with a slight chance of X-class flares. Slight chance of a glancing CME late 6th or early 7th Jan, with a G1 Minor geomagnetic storm possible.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with three M-class flares observed, all originating from AR3947 in the northeast of the visible disc. The peak flare was a M3.1 at 06/0152 UTC.

There are currently ten sunspot regions on the visible disc. Despite the number of spots on the Earth facing-disc, many are small and generally magnetically simple, with most showing little signs of significant growth or some slight decay in the last 24 hours. AR3947 in the northeast is the largest and most magnetically complex region. It has been responsible for the majority of recent activity, producing three lower X-class flares since rotating into view over the eastern limb. This region features several moderately sized spots, including a delta configuration within its intermediate spots, with no significant growth in the last 24 hours. AR3939, though currently magnetically simple, saw two C-class flares, one at 04/1444 UTC and another at 04/1827 UTC that generated significant coronal mass ejections (CMEs) on 04 Jan but has since remained relatively stable and soon to rotate of the western limb. It is likely both of these CMEs will pass ahead of Earths orbit, however there is a slight chance that the latter CME may deliver a glancing blow late on Day 1 (06 Jan) or early on Day 2 (07 Jan).

No new Earth-directed CMEs were observed in available coronagraph imagery.

Solar Wind / Geomagnetic Activity: Solar wind speeds observed by ACE at L1 were elevated at around 580-600km/s slowly declining to 530km/s as the HSS from CH05/+ connection fades. Density was below average levels throughout. The Interplanetary Magnetic Field, Bt, has been weak, peaking at 8nT. The north-south component, Bz, fluctuated between negative and positive through much of the period, ranging between +7nT and -8nT. The Phi angle was mostly positive (away from the Sun).

Geomagnetic activity was mainly Unsettled to Active (Kp3-4) throughout the period.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES-18 was close to the S1 Minor Storm threshold at the start of the period, with a brief peak at 1.0pfu, slowly trending downwards from 05/1800 UTC.

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High energy electron flux (greater than 2MeV) at GOES16 was at moderate levels with the associated 24 hr fluence staying below the Active threshold. The 06/0000 UTC fluence observation was 1.88e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Activity is forecast to be Moderate to High, with further M-class flares expected and a slight chance of further isolated X-flares, mainly from AR3947 in the northeast.

Solar Wind / Geomagnetic Activity: There is a slight chance of a glancing blow from a CME later on Day 1 (06 Jan) or early on Day 2 (07 Jan), but it is more likely the CME will pass ahead of Earth's orbit. Earth's connection to a HSS associated with CH05/+ is expected to wane over the next few days. Elevated solar winds are likely to slowly decline on Day 1 (06 Jan), perhaps returning to background levels by Day 3 (08 Jan).

Geomagnetic conditions are expected to be mainly Quiet to Unsettled (Kp1-3) through the period, some Active (Kp4) intervals likely with a slight chance of a G1 Minor geomagnetic storm interval (Kp5) later Day 1 (06 Jan) or early Day 2 (07 Jan) if a glancing blow occurs from the aforementioned CME. Quiet to Unsettled conditions are expected on Days 3 and 4 (08-09 Jan) as CH HSS continues to wane and possibly any lingering glancing CME effects.

Energetic Particles / Solar Radiation: GOES18 high energy proton flux has now decreased back below the S1 threshold after recent enhancement. There is a slight chance of further enhancement over the next few days should any further significant flares occur from the western hemisphere of the disc.

GOES16 high energy electron flux briefly reached High levels, with a peak flux of 1070pfu at 05/1950UTC, but soon returning to Moderate levels. However, electron flux may see further peaks of High levels later in the period as the influence of the HSS begins to wane. The associated fluence is expected to remain below the Active threshold, however there is a slight chance of exceeding the active threshold later in the period due to the risk of rising flux levels.

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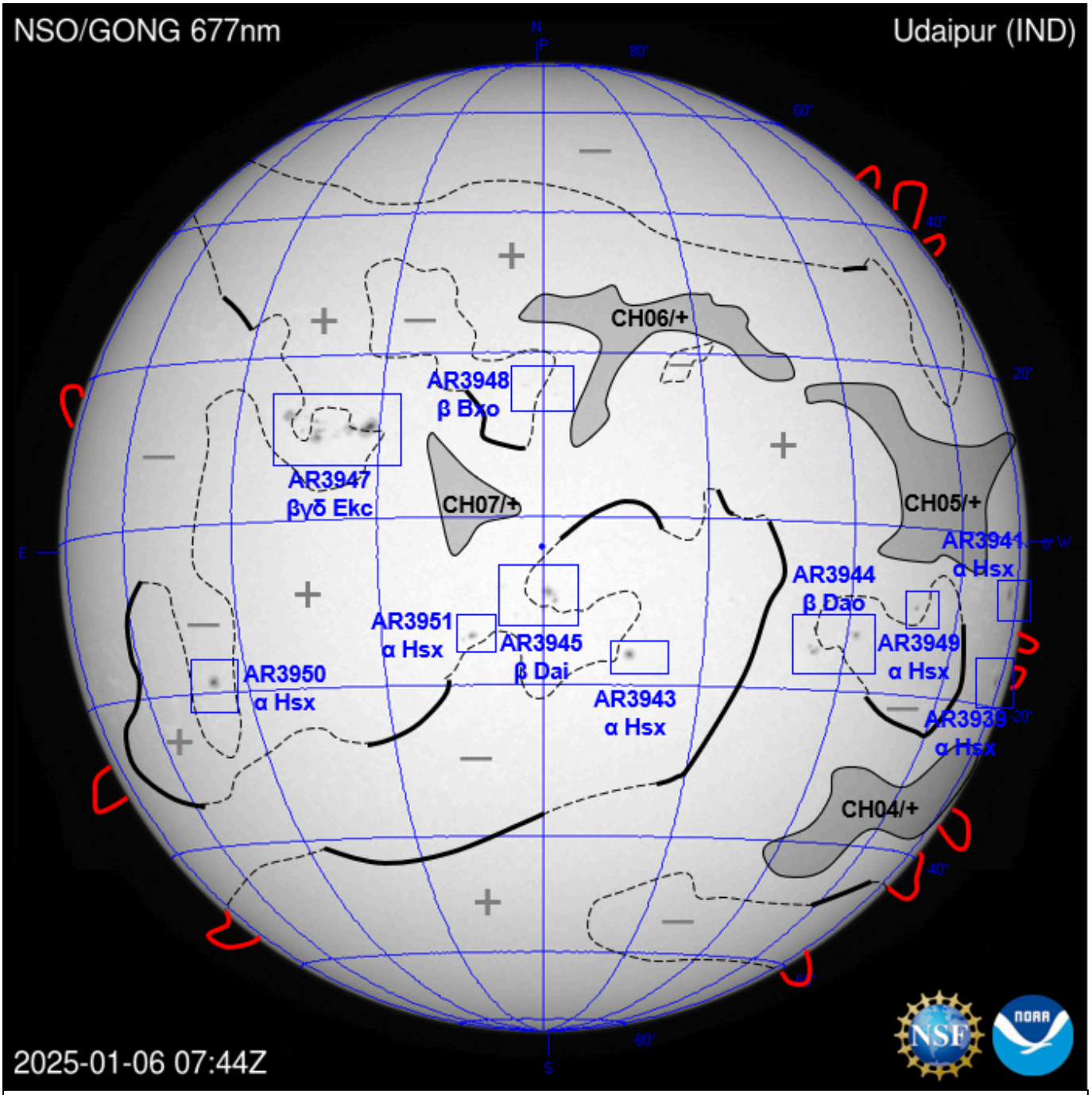
Figure 1: Solar Synoptic Map valid 06/0744 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

Two CMEs occurred from AR3939 in association with C-flares at 04/1444 and 04/1827. It is likely both of these CMEs will pass ahead of Earths orbit, however there is a slight chance that the latter CME may deliver a glancing blow late on Day 1 (06 Jan) or early on Day 2 (07 Jan).

Earth has been connected to a HSS associated with CH05/+ in the northwest of the solar disc since 04/1400UTC. This coronal hole was originally a larger hole consisting of CH05/+ and CH06/+ which has since been split into two CHs. Both coronal holes are persistent, although were smaller and further to the solar east on last rotation. Solar winds have been declining slowly over the past 12 hours and are expected to continue this decline over the coming days. Initially Elevated slowly declining to Slightly Elevated solar winds are likely on Days 1 and 2 (06-07 Jan), perhaps returning to background levels by Days 3 and 4 (07-08 Jan). It should be noted however that the density in the HSS is low and hence the resulting geomagnetic conditions are not expected to be significantly enhanced from the HSS connection alone. MOSWOC ENLIL has the connection to the HSS too late, but its slow decline suggests the connection should wane in the coming days.

Geomagnetic conditions are expected to be mainly Quiet to Unsettled (Kp1-3) through the period, some Active (Kp4) intervals likely with a slight chance of a G1 Minor geomagnetic storm interval (Kp5) later Day 1 (06 Jan) or early Day 2 (07 Jan) if a glancing blow occurs from the aforementioned CME. Quiet to Unsettled conditions are expected on Days 3 and 4 (08-09 Jan) as the CH HSS continues to wane and possibly any lingering glancing CME effects.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	20	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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Figure 2: MOSWOC Enlil output, showing the CME that left the Sun on 04 Jan to mainly pass to ahead of Earth, hitting St-A during the second half of 06 Jan.

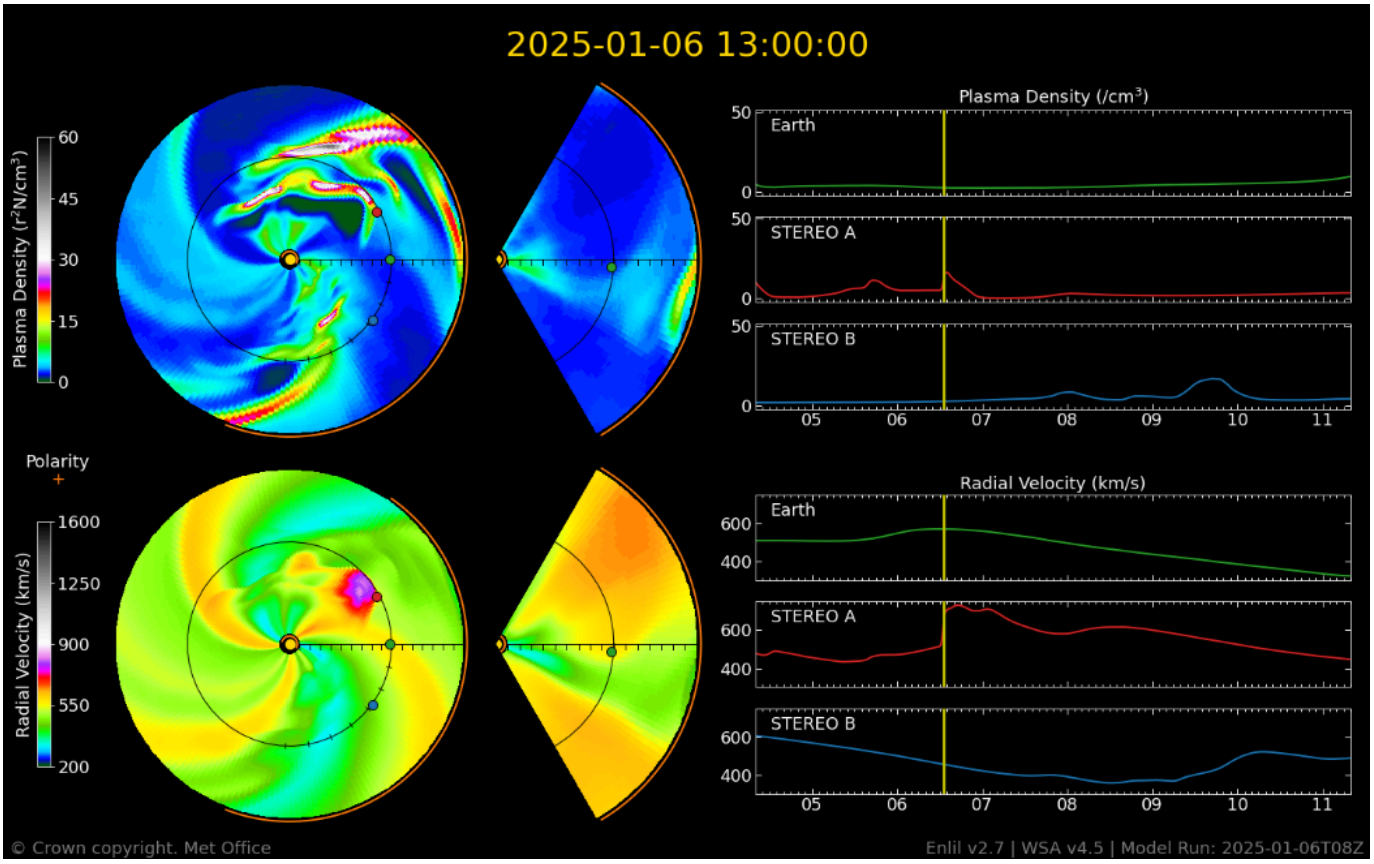
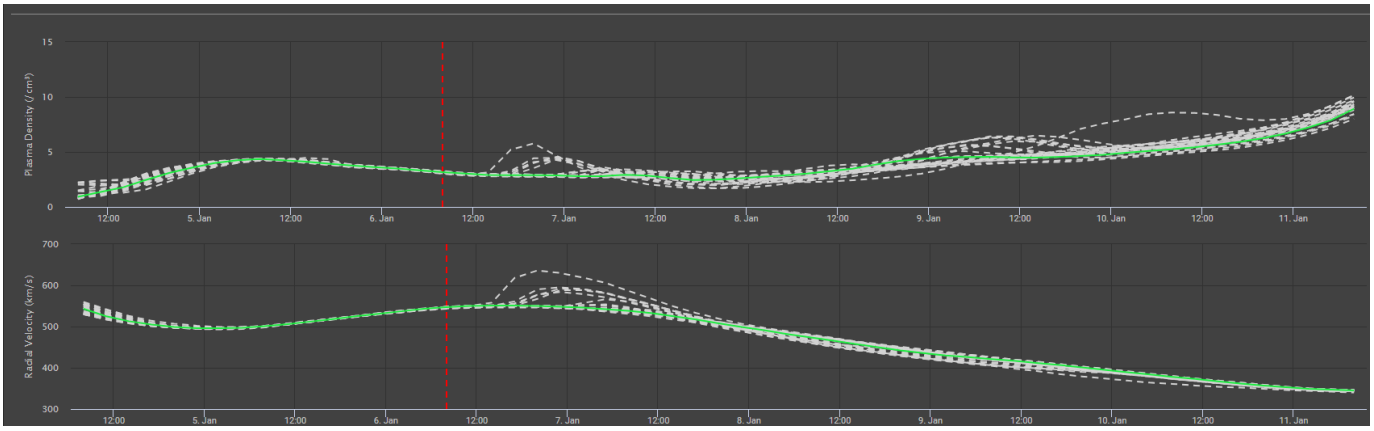


Figure 3: MOSWOC Ensemble spread.



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Radio Blackouts - X-Ray Flares

Solar activity has been Moderate with three M-class flares observed, all originating from AR3947 in the northeast of the visible disc. The peak flare was a M3.1 at 06/0152 UTC.

There are currently ten sunspot regions on the visible disc. Despite the number of spots on the Earth facing-disc, many are small and generally magnetically simple. AR3947 in the northeast is the largest and most magnetically complex region. It has been responsible for the majority of recent activity, producing three lower X-class flares since rotating into view over the eastern limb. This region features several moderately sized spots, including a delta configuration within its intermediate spots, with no significant growth in the last 24 hours. Most spots have shown either no significant change or some slight decay in the last 24 hours. AR3944 saw a decrease in its leaders size, AR3945 lost some trailing spots and, AR3943 also lost its trailers making it a alpha group again. AR3939, though currently magnetically simple, generated two significant coronal mass ejections (CMEs) on 04 Jan but has since remained relatively stable and soon to rotate of the western limb.

GOES-16 SUVI 171 imagery shows notable looping on the southeast limb with far-sided data showing a returning region likely to emerge in the coming 48 hours with a previous history of flares. There is also a hint of plage on the GONG intensitygram around the same region.

Given that AR3947 has been the most active region and will remain on the solar disc for the next four days, the flare risk is being maintained at a steady level throughout this period, pending any further developments.

Overall, activity is forecast to be Moderate to High, with further M-class flares expected and a slight chance of further isolated X-flares, mainly from AR3947.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	80	80	80	80
Very Active	R3-R5 (X Class)	No	20	20	20	20

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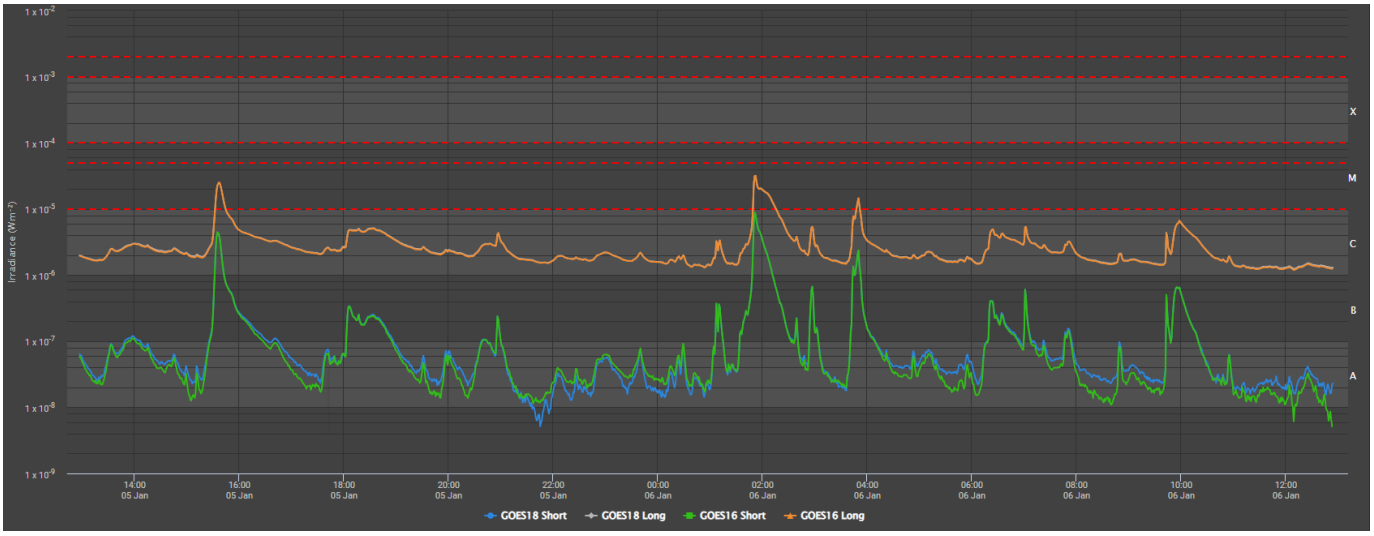
Figure 4: GOES16&18 X-ray trace.



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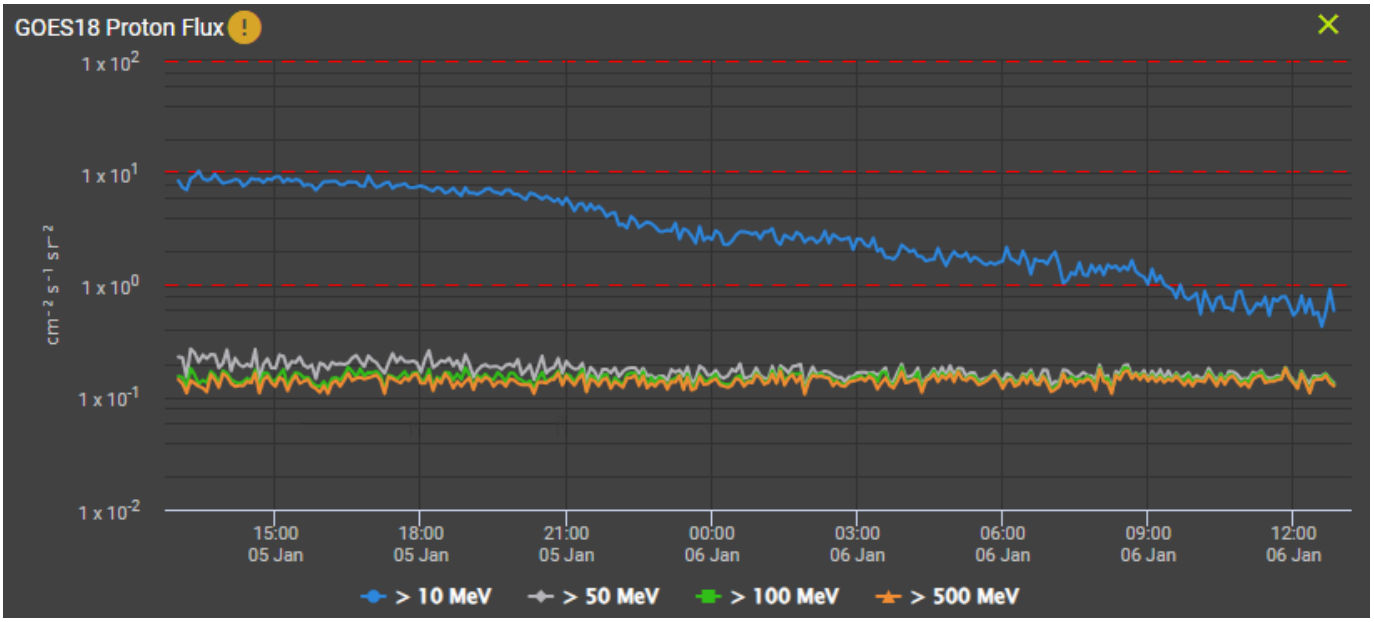
Solar Radiation Storms (High Energy Protons)

GOES18 high energy proton flux has now decreased back below the S1 threshold after recent enhancement. This enhancement came in association with a C9.1 flare from AR3939 in the southwest of the disc. There is a slight chance of further enhancement over the next few days should any further significant flares occur, mainly from AR3939. This risk is maintained throughout despite AR3939 rotating of the western limb as active sunspot region AR3947 makes its way into the western hemisphere by the end of Day 3 (08 Jan).

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: GOES18 proton Flux showing a declining trend.



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High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 is currently at moderate levels following the connection to the high speed stream from CH05+. This HSS has resulted in strong solar winds, which may have charged the radiation belts with electrons. As a result, it is possible that we may see electron levels peak at high during their diurnal max. Any notable geomagnetic activity as a result of a possible glancing blow from a CME that left the Sun on 04 Jan, may cause the electron belts to become surprised away from GEO on Day 2 (07 Jan), although this is viewed with low confidence, before then expanding back out and causing the electron flux to rise again once any geomagnetic activity has ceased.

The associated 24-hour fluence is expected to remain below active levels overall. However, due to the potential for rising electron flux levels, there is a slight chance that fluence could exceed the active threshold, as suggested by MOSWOC REFM.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	5	10	20	20
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 6: GOES16 Electron flux, showing a increasing trend towards High levels.

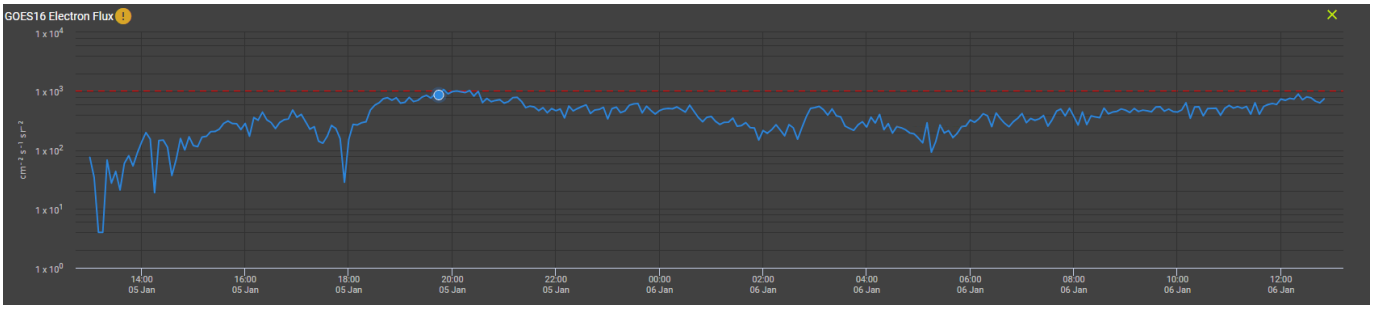

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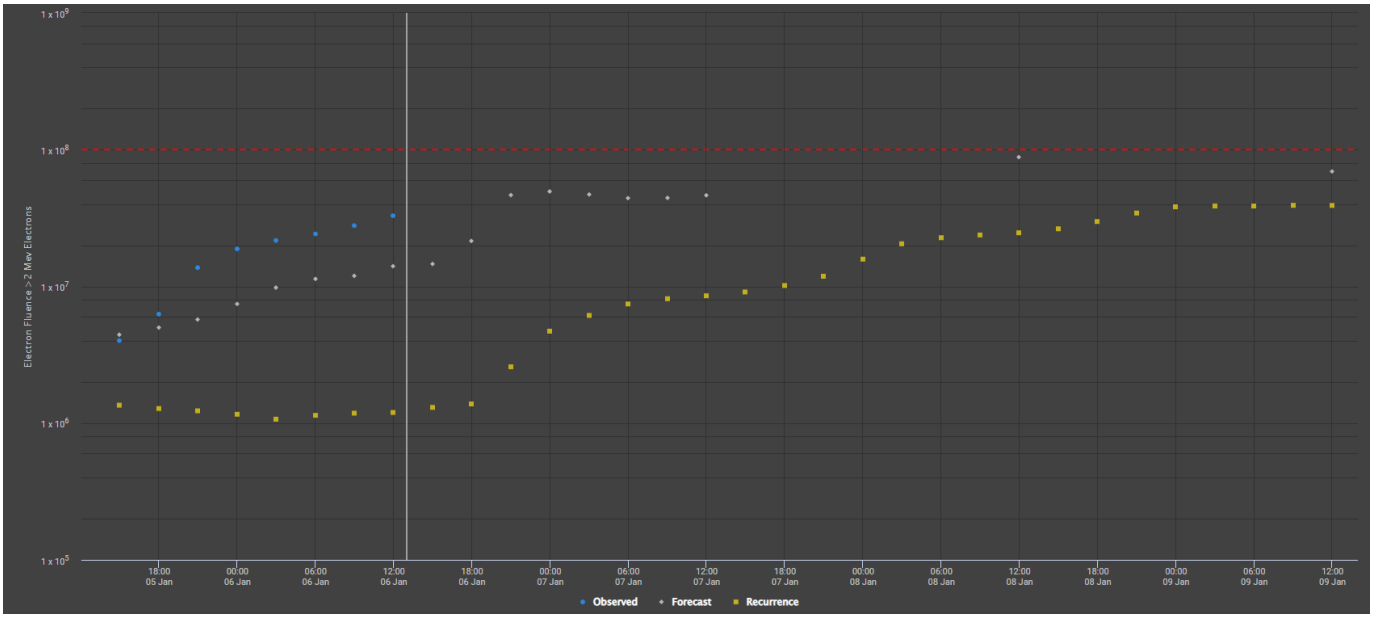
Figure 7: MOSWOC REFM output, showing electron fluence below the Active threshold but a general rising trend.



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